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Reviews

Management of local burn wounds in the ED

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Abstract Each year there are over 500,000 burns that present to the emergency department (ED). Most burns are minor, and their care focuses on local wound management. The current article will present a typical case and then review the epidemiology, pathophysiology, diagnosis, and management of minor burns in the ED.

1. Case presentation

A 5-year-old boy presents to the emergency department (ED) 20 minutes after sustaining scald burns to the upper extremities while reaching for a pot of boiling soup. The child is in considerable pain and has several small blisters over his forearms with surrounding erythema covering an area of approximately 4% of his total body surface area (TBSA). The child is otherwise healthy; his immunizations are all up to date and there are no known drug allergies. How should this patient be managed?

2. Epidemiology and etiology of minor burns

Despite decreases in the number of burns over the last decade [1], there are still more than 1 million burn injuries each year in the United States [2], resulting in over 500,000 ED visits [3], 45,000 hospital admissions, and 4500 deaths from burns per year. Fortunately, most burns are superficial and minor, involving less than 5% of the TBSA [4]. With improvement in fluid resuscitation, mortality from burns is usually the result of sepsis and/or concomitant inhalational injury. Most superficial burns in children result from scalding with hot liquids. In adults, many burns also result from hot liquids, but deeper burns are secondary to direct contact with flame, hot objects, chemicals, or electricity. In the current article, a burn is considered minor if it is a first- or second-degree burn involving less than 5% TBSA [5]. Circumferential burns, those involving the face, ears, eyes, perineum, or joints, and burns in patients with significant comorbidities (eg, renal failure, diabetes) are also not considered minor.

3. Pathophysiology of burns

The primary injury in burns is the result of irreversible tissue necrosis at the center of the burn due to exposure to heat, chemicals, or electricity. The extent of this injury is dependent on the temperature (or concentration) and the duration of exposure as well as the vascular supply and thickness of the injured skin [6,7]. Surrounding the central zone of necrosis is a zone of ischemia in which there is a reduction in the dermal microcirculation [8]. This ischemic zone may progress to full necrosis over the next few days unless the ischemia is reversed [9]. At the periphery of the burn is a third zone of hyperemia characterized by a

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Fig. 1 A superficial partial-thickness (second-degree) burn. Note presence of blisters with surrounding area of erythema.

reversible increase in blood flow. The pathogenesis of reduced dermal microcirculation in the zone of ischemia is complex and incompletely understood [10]. Activation of the clotting and complement systems by the initial insult is followed by the local recruitment of inflammatory cells with the release of a large number of inflammatory mediators [11-13] that increase vascular permeability and result in transudation of large amounts of fluid and protein into the interstitial space [14]. Reperfusion injury also occurs as the dermal circulation is restored resulting in the production of a large number of toxic oxygen radicals further contributing to the injury [15]. A great deal of research has been directed to developing methods aimed at attenuating the inflammatory response. Antioxidants such as glutathione and xanthine oxidase inhibitors as well as the free radical scavengers vitamins C and E have been used with some success to treat burns in both animals and humans [16,17]. In addition, topical and systemic treatments of burns with anti-inflammatory agents such as ibuprofen and corticosteroids have also met with a variable degree of success [18-20]. A phase II randomized clinical trial of a monoclonal antibody directed against intercellular adhesion molecule-1 in 110 patients with partial-thickness burns has recently been reported [21]. Patients treated with the monoclonal antibody had a significantly increased percentage of wounds that healed spontaneously in less than 21 days. However, there is no evidence to support the routine use of any of the above agents for minor burns.

4. Burn classification

A burn is an injury that occurs as a result of exposure of the tissues to thermal, chemical, or electrical energy. Burns are classified based both on their depth and the surface area of the skin that is involved. First-degree burns that only involve the epidermal layer result in pain and erythema and usually heal within several days without any scarring. Second-degree burns involve the entire epidermis and part of the underlying dermis. They are further classified as superficial partial-thickness or deep partial-thickness burns based on the depth of injury to the dermis. This distinction is important because many deep partial-thickness burns heal with significant scarring. Superficial partial-thickness burns are characterized by erythema, blister formation, and weeping (Fig. 1). They are very painful, and the skin remains sensitive to touch and blanches when pressure is applied, indicating preservation of the dermal circulation. These superficial partial-thickness burns generally heal within 2 weeks with minimal scarring. In contrast, deep partial-thickness wounds involve the reticular as well as papillary layers of the dermis and are characterized by the presence of a nonelastic, red or white layer on top of the burn that often does not blanch with pressure (Fig. 2). Because many of the epithelial appendages that give rise to restoration of the epidermis are destroyed, these burns require up to 3 weeks to heal and may be associated with significant scarring. Full-thickness or third-degree burns involve the entire epidermis and dermis and may appear as white, thick brown, or tan and have a leathery texture (Fig. 3). These burns are not sensitive to the touch and do not blanch and require excision. Both deep partial-thickness burns that do not heal within 21 days and full-thickness burns should be excised surgically and healed by the application of split-thickness skin grafts. Although multiple methods have been investigated to help determine burn depth, the clinical examination (especially by an experienced burn specialist) remains the most widely used technique [22,23]. Use of vital dyes, ultrasonography, thermography, and magnetic resonance imaging are also under investigation.

The extent of the burn is expressed as the percentage of the TBSA that is involved and can be calculated using specialized age-specific body charts, such as the Lund Browder chart [24]. The extent of injury can also be estimated using the "Rule of Nines," which assigns 9% to the head and each upper extremity and 18% to the anterior

Fig. 2 A deep partial-thickness (second-degree) burn. Note presence of pink-colored dermal appendages within burn.

Fig. 3 A full-thickness (third-degree) burn.

trunk, the posterior trunk, and each lower extremity. The remaining 1% is assigned to the genitalia. For small burns, the area involved can be estimated by comparing its extent to the palm of the hand, which represents approximately 1.0% of the TBSA [25,26]. Studies show that many physicians tend to overestimate the extent of the burn by up to 100%, and that there is high interrater variability [27,28]. Therefore, use of standardized burn charts is recommended. A computer-based program is also available, which calculates TBSA, and can be downloaded onto a personal data assistant [29].

Burns are classified as minor or major based on a combination of factors including age, depth, extent, location, and comorbidities such as inhalation injury (Table 1). All but the minor burns should be managed by a burn specialist, preferably at a designated burn center.

5. Initial management of local burns wounds

5.1. Cooling of the burn

Evidence from multiple animal and human studies supports the use of cooling in the immediate management of burns [30,31]. Cooling of burns with cold (15-25°C) tap water has been shown to reduce pain, the depth and extent of the injury, the need for surgical excision of the burn, scarring, and mortality. Because ice or ice water may increase tissue injury, their use should be avoided [32].

5.2. Management of blisters

Despite considerable controversy, we recommend leaving small blisters intact [33]. Large or very tense blisters may be aspirated or ruptured under sterile conditions. Multiple studies have evaluated the in vitro effects of the fluid from burn blisters. These studies have demonstrated both beneficial [34-36] and detrimental [37-39] effects of the burn blister fluid on wound healing contributing to the ongoing debate regarding how burn blisters should be managed. In contrast, few studies have evaluated the effects of burn blister management in vivo both in animals and in humans. In a study of 14 human volunteers in which partial-thickness burns were created, those burns whose blisters were left intact healed faster than those that were ruptured and debrided [40]. A single case report, comparing the healing of burn blisters that were debrided or left intact also demonstrated faster healing when blisters remained intact [41]. These results are further supported by a porcine study in which removal of the necrotic epidermis slowed reepithelialization, increased the rate of infection, and resulted in deeper scars than when the necrotic epidermis was left intact [42]. The above results are also in agreement with the monumental studies performed by Winter [43], Hinman et al [44], and Wheeler and Miller [45] that clearly demonstrated that creating a moist wound environment (as when leaving blisters intact) was beneficial to wound healing.

5.3. Local burn wound therapy

The goals of local burn wound management are to reduce pain and contamination, prevent infection, and promote rapid healing with minimal scarring. The ideal burn wound therapy should also be comfortable and convenient for patients as well as economical. First-degree burns do not require any specific topical therapy. Deep second-degree and third-degree burns should be temporarily covered by a

Table 1 Classification of burn severity

	Minor	Moderate	Major
Criteria	<10% TBSA in adults; <5% TBSA in children or elderly; <2% full-thickness burn	10%-20% TBSA in adults; 5%-10% TBSA in children or elderly; 2%-5% full-thickness burn; high-voltage injury; suspected inhalation injury; circumferential burn; concomitant medical problem predisposing to infection (eg, diabetes, sickle cell disease)	>20% TBSA in adults; >10% TBSA in children and elderly; >5% full-thickness burn; high-voltage burn; any significant burn to face, eyes, ears, genitalia, or joints; significant associated injuries (eg, fracture, other major trauma)
Disposition	Outpatient management	Hospital admission	Referral to burn center

Adapted from *J Burn Care Rehabil* 1990;11:98-104 and from Guidelines for the Operations of Burn Units. Resources for Optimal Care of the Injured Patient: 1999, Committee on Trauma, American College of Surgeons.

Table 2 Summary of treatment for minor burns

- Exclude and/or treat associated injuries
- Inhalation injury
- Nonburn trauma
- Cool burn with cold water
- Administer analgesic agent
- Irrigate with soap and water
- Leave unruptured blisters intact
- Carefully debride any nonadherent necrotic epidermis
- Treat burn with occlusive dressing or topical antimicrobial agent and absorptive dressing
- Administer tetanus prophylaxis if required
- Elevate extremity burns
- Follow-up within several days

topical antimicrobial (to minimize burn wound colonization and contamination) agent and referred to a burn specialist for more advanced therapies such as excision and grafting. Early and aggressive surgical debridement of deep dermal and full-thickness burns has resulted in substantial reductions in burn mortality and morbidity, infection rates, hospital length of stay and costs, as well as reduced rates of hypertrophic scarring [46]. Routine use of systemic antibiotics is not supported by the evidence [47].

Superficial partial-thickness burns may be managed with a topical antimicrobial agent or any of a number of synthetic or biological occlusive dressings. Both methods create a moist wound environment beneficial to wound reepithelialization and angiogenesis. Direct comparisons of the various antimicrobial agents and occlusive dressings are limited but suggest that occlusive dressings are more convenient and less painful [48]. Heavily contaminated or infected burns and those with a large amount of exudate or weeping are probably best managed with topical antimicrobial agents and absorbent dressings.

Various formulations of silver have been used for the management of burn wounds for over 200 years [49]. Traditional silver containing topical therapies, such as silver sulfadiazine and silver nitrate, are still widely used [50], although experimentally, they have been shown to be associated with cellular irritation and toxicity as well as inactivation by wound fluid requiring frequent and often painful reapplication and dressing changes [51,52]. Acticoat (Smith & Nephew, Largo, Fla) is a dressing made of high-density polyethylene mesh with a polyester/rayon core that is coated with nanocrystaline silver [53]. This dressing slowly releases small amounts of silver preventing the cytotoxic effects associated with other silver-containing topical agents such as 1% silver sulfadiazine with or without 0.5% chlorhexidine digluconate [54]. A randomized, match-pair study evaluating the safety and efficacy of Acticoat found the dressing to be more effective in preventing mortality from aminoglycoside-resistant *Pseudomonas aeruginosa* than silver sulfadiazine [55]. This study also demonstrated that Acticoat was more effective at reducing pain and improving wound healing than the use of silver sulfadiazine alone. A new type of Acticoat termed Acticoat 7, which provides antimicrobial activity for up to 7 days, is also available. Another silver impregnated dressing based on sodium carboxymethyl-cellulose spun into absorbent hydrofibers (Aquacel Ag; ConvaTec International, Princeton, NJ) has also been described [56] and has been found useful in treating superficial partial-thickness injuries in our burn center.

A large number of non–silver containing topical antimicrobial agents are available (eg, bacitracin and mupuricin); however, there is little evidence demonstrating the superiority of one agent over the others. Because of its greater tissue penetration, sulfamylon is often preferred over extensive deep burns and those overlying cartilage such as the nose and ears. Over the last 2 decades, there has been recognition of the role of methicillin-resistant *Staphylococcus aureus* (MRSA) in causing wound contamination and infection in burn patients. Thus, topical antimicrobial agents should be active against MRSA, and emergence of resistant organisms remains a constant threat. A recent study comparing the activities of Acticoat, 0.5% chlorhexidine acetate, and 2% fusidic acid against MRSA in a burn wound model demonstrated that Acticoat and fusidic acid were both effective, although fusidic acid was most effective [57].

A large number of synthetic and biological dressings have been evaluated for the local management of burn wounds [58]. When properly used, occlusive dressings do not increase the risk of wound infection [59]. DuoDerm (Convatec, Skillman, NJ) is an occlusive hydrocolloid dressing that has been compared to 1% silver sulfadiazine in patients with superficial partial-thickness burns. One study demonstrated that patients treated with DuoDerm had less pain, better acceptance and compliance, and more pleasing aesthetic results than those treated with silver sulfadiazine [60]. A recent study comparing DuoDerm to a biocomposite dressing, Biobrane (Dow Hickman, Sugar Land, Tex), found that DuoDerm was just as effective yet less expensive than the collagen-based dressing [61]. Although we use DuoDerm as a dressing of donor sites, we do not use it for burns because it tends to absorb exudate and can become malodorous, requiring frequent dressing changes. Because they do not absorb exudate, the polyurethane films (such as Tegaderm [3M, St. Paul, Minn] and OpSite [Smith & Nephew]) should only be used when the wound becomes more dry [62]. Mepitel is a soft, flexible silicone mesh dressing that adheres gently to the wound bed that is designed to enable wound exudate to escape onto a secondary dressing placed above. Several studies have demonstrated that partial-thickness thermal burns treated with Mepitel heal more quickly than with silver sulfadiazine [63,64]. Biological dressings based on collagen and/or skin cells such as Integra, TransCyte, and Apligraft are best reserved for the burn specialist because they usually require prior surgical debridement. A summary of the management of minor burns is presented in Table 2.

6. Pain management

Pain management is an important yet often neglected aspect of burn wound care [65]. Mild pain can be managed with a nonsteroidal anti-inflammatory agent or acetaminophen. Moderate to severe pain should be managed by an opioid with or without a nonsteroidal anti-inflammatory agent or acetaminophen. Patients with major burns should be managed with frequent intravenous boluses of an opioid titrated to pain control [66].

7. Indications for admission to a burn unit

Deep burns and those that involve large and/or specific areas of the body (such as the face, perineum, pretibial areas, feet, hands, and circumferential burns of the extremities) should be referred to a burn center [67]. The presence of significant comorbidities (such as cardiac or pulmonary disease or diabetes) should also indicate the need for prompt referral.

8. Burn wound surveillance and long-term follow-up

Burns are dynamic injuries that often progress in depth and extent over the first few days. Therefore, close surveillance of all burns is necessary. The absence of early and complete healing within 7 to 10 days suggesting that the burn is deep or infected warrants prompt referral to a burn specialist or center. The American Burn Association has published guidelines that address the management of burns [68]. However, these guidelines are very limited. In particular, these guidelines do not address the areas of uncertainly discussed above and call for further research.

9. Conclusions and recommendations

In the patient described in the vignette, the diagnosis of a minor superficial second-degree partial-thickness burn can be made on the basis of the clinical examination. The presence of blisters and the fact that burn is sensitive to touch, soft, and blanches with pressure are evidence that it is superficial and only partial thickness. The patient should receive an oral analgesic such as acetaminophen with or without codeine. Because it is small, does not involve any high-risk areas, and there are no comorbidities, one might consider cooling the patient's burn with room temperature water or saline solution until the pain is relieved. The burn should then be cleaned with a mild soap and water, and the small blisters should be left intact. The burns may then be covered with Acticoat (or Acticoat 7), Aquacel Ag, or a layer of a topical antimicrobial agent and an occlusive absorptive dressing. The patient was seen by his pediatrician 2 days later, at which time there was no evidence of infection. The burn healed without scarring within 14 days of injury. Exposure to sunlight was avoided over the next year by having the patient apply sunscreen and wear long sleeves that covered the burns (clothes specifically treated with sun blocking agents may also be used). The mother also received instructions on how to reduce the risk of thermal injuries in the future.

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